Maternal Mortality Trends in Mexico: State Differences

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Abstract

This study examines trajectories in the Maternal Mortality Ratio (MMR) at the state level in Mexico. Using the historical time series of MMR by state compiled by the Mexican National Health Information System, I observe state MMRs trends from 1990 to 2010. Although I find a declining trend over this period, the actual decline has been slower than the expected one. As a result, it is very likely that the Millennium goal regarding maternal mortality won't be attained. I explore the relationship between state-level covariates and the MMR. The study finds that the use of contraceptive methods has a negative and significant relationship with the MMR which supports other studies findings that access to the means of planning childbearing is associated with lower levels of maternal mortality.

Introduction

Maternal mortality has raised general concern around the world because about 500,000 women each year die of maternal causes. Developing countries have implemented a variety of strategies to reduce their levels of maternal mortality, but most of these efforts have not led to the achievement of established goals. In 2000, the General Assembly of the United Nations included maternal health as one of their Millennium Development Goals (MDG), giving new standard benchmarks by which nations could evaluate their progress in reducing maternal mortality.

High levels of maternal mortality are strongly correlated with high levels of social inequality, especially unequal access to health services. Since most maternal deaths could be avoided by the provision of adequate medical care, access to pre-natal care and deliveries attended by trained providers are essential pathways to reducing the risk of death during pregnancy, delivery, and the perinatal period.

In the case of Mexico, the level of maternal mortality has differed broadly across the 31 states and the Federal District, mirroring substantial socioeconomic disparities across states. To the extent that these mortality differentials between states persist across time, they may reveal the impacts of structural inequality in the health care system across the country. The objective of the present work is to analyze trajectories in the Maternal Mortality Ratio (MMR) at the state level in Mexico. The consequences of maternal mortality mostly affect disadvantaged families, worsening their already fragile situation. Identifying states where maternal mortality is persistently high, persistently low, or changing through time, can help identify successful or detrimental policies and practices at the state level. This knowledge could guide other states' adoption of policies and thereby improve maternal mortality across the nation.

Background

The last few decades have been characterized by growing interest in maternal mortality worldwide. Several international meetings concluded with goals to reduce maternal mortality levels. For example, the 1987 International Conference entitled "Maternal Mortality Without Risk" and the Millennium Summit in 2000 both highlighted maternal mortality reduction as a matter of international concern (Freyermuth 2009; Lozano, Nuñez, Duarte, and Torres 2005; Mills 2006).

On September 8th 2000, the United Nations General Assembly adopted the United Nations Millennium Declaration (Lozano et al. 2005). Countries around the world committed their nations to reduce extreme poverty through a series of time-bound targets known as the Millennium Development Goals. The fifth goal focuses on improvement of maternal health by:

1. Reducing the maternal mortality ratio (MMR) by 75% between 1990 and 2015, and
2. Universalizing access to reproductive healthcare by 2015.

According to the World Health Organization (WHO), the annual rate of decline must be 5.5% or more to reduce the MMR by three quarters between 2000 and 2015. The observed annual rate of decline worldwide was 2.3% by 2010 (WHO 2010), which raises international concern regarding the feasibility of reaching this goal. Although the global rates have been in slow decline, countries such as Malaysia, Sri Lanka, and Honduras have succeeded in reducing their maternal mortality levels in relatively short periods. The strategies implemented in these countries have been analyzed to help other countries to reduce the number of maternal deaths (Liljestrand and Pathmanathan 2004; Prata, Passano, Screenivas, and Gerdts 2010).

According to Lozano and coauthors, maternal mortality is hard to measure because of conceptual and practical issues. They explain that although the WHO has clearly defined maternal mortality[1] and there are specific definitions for the four types of maternal deaths (direct obstetric, indirect obstetric, late maternal, and related to the pregnancy), there are still a significant number of deaths that are not properly registered as maternal deaths around the world (2005).

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[1] Maternal death is defined as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration or site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental causes."

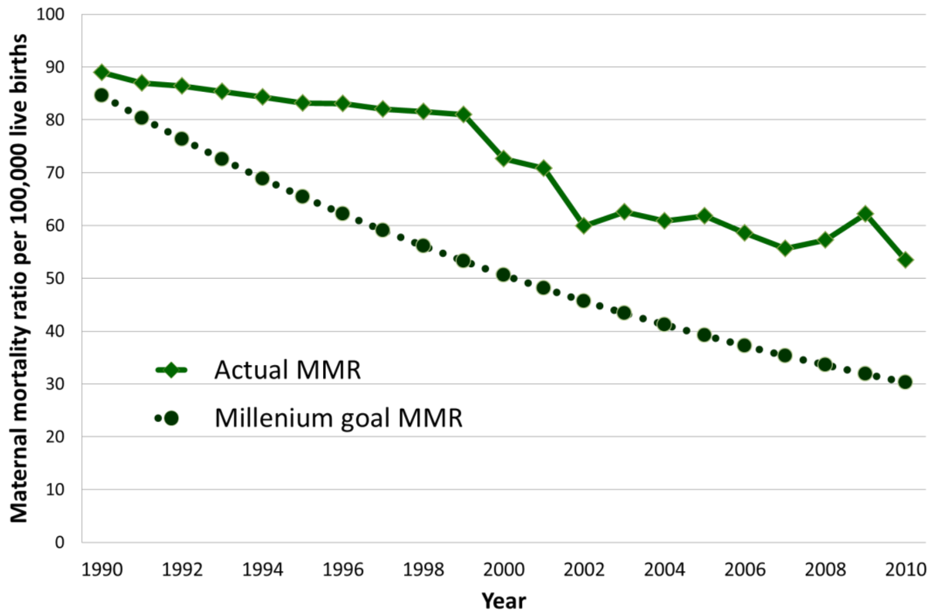
Lozano and colleagues also explain that correcting the number of deaths is not the only challenge in the measurement of maternal mortality. The other important challenge arises from the fact that it is very difficult to measure the maternal mortality rate since obtaining the number of pregnant women is often difficult or impossible(2005). For this reason, I use the maternal mortality ratio (MMR), which uses the number of live births in the denominator as a proxy of the number of pregnancies (Cárdenas 2009a, Lozano et al. 2005).

The Case of Mexico

Mexico has dramatically decreased its MMR over the last 60 years, but in recent years the decline has slowed. In 1990, there were an estimated 89 maternal deaths per 100,000 live births. However, some studies have reported that the MMR was underreported until 2002, when health authorities started to correct the MMR using the modified Reproductive Age Mortality Survey (RAMOS) method (UNDP 2010, Freyermuth and Cárdenas 2009; Freyermuth 2009; Lozano et al. 2005). The RAMOS method consists of identifying all deaths among women of reproductive age (usually women between 15 and 49 years old) and then, conducting interviews with their family members and acquaintances (verbal autopsies). The difference between the RAMOS method and its modified version is that the later only conduct interviews if the cause of death is one of the 46 causes selected by the Mexican Ministry of Health (Freyermuth and Cárdenas 2009). The verbal autopsies allow researchers to identify more accurately deaths to women that were related to pregnancy or delivery, thereby improving the measurement of maternal mortality.

Figure 1 shows that although the MMR has declined over time, the rate of decline has not been sufficient to reach the Millennium goal.

Figure 1. Maternal Mortality Ratio, 1990-2010



In 2011, the Mexican Federal government reported that Mexico won't be able to achieve the Millennium goal regarding maternal mortality decline (Saldierna 2011, Notimex 2011). According to the health authorities, one of the factors that prevented Mexico from decreasing its MMR by 75% was the fact that the number of maternal deaths was under-reported in 1990. So, since 2002 the Ministry of Health has been reporting a more accurate measure, which places the country farther from the original goal (Presidencia de la República 2011; Freyermuth and Sesia 2009). In other words, the target was set based on an artificially low MMR due to flawed data for the baseline in 1990.

Progress toward reduction in the MMR in Mexico is also impacted by the changing age distribution of fertility. The distribution of maternal deaths is very different across age groups and the highest risk of maternal death is experienced by the oldest age groups. On the one hand, the highest maternal mortality ratios are observed among older age-groups, although that is the group which experiences the lowest number of deaths (Figure 2). On the other hand, teenage mothers have also shown a higher risk of maternal death, as well as higher health hazards in general (Beck et al. 2010, Cárdenas 2009b, Freyermouth 2009, Freyermouth and Sesia 2009).

Figure 2. Maternal deaths and MMR by Age Group, 2010

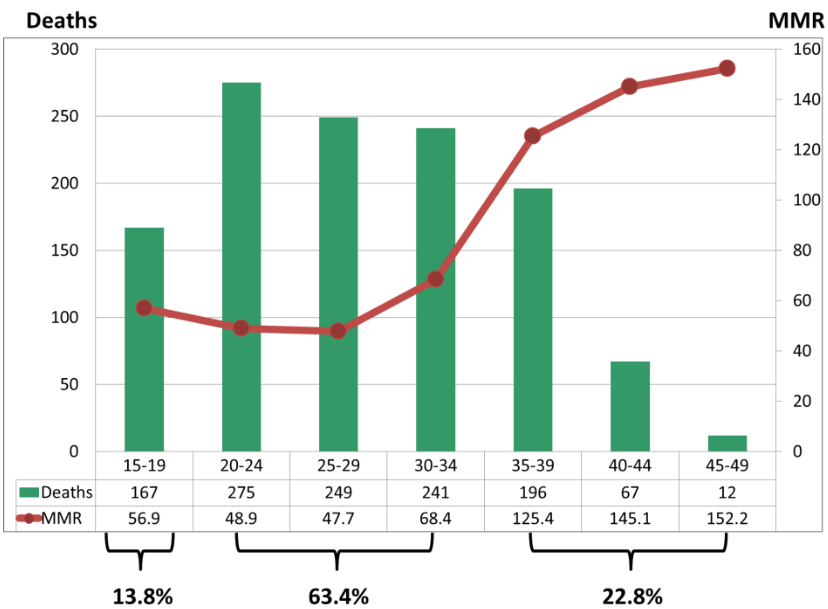


Table 1 shows that in 2010, the main causes of maternal death in Mexico were preeclampsia-eclampsia, hemorrhage, septic shock, neoplasm, embolism, and abortion. Together, these causes represent 65.8% of the total maternal deaths (Health Ministry 2011a). Most of the deaths by these causes could have been prevented if the women would have had adequate prenatal care (Cárdenas 2009b; Freyermouth 2009; Freyermouth and Sesia 2009; Prata et al. 2010; Romero, Espitia, Ponce, and Huerta 2007).

Table 1. Main causes of maternal death in Mexico, 2010

Cause	%
Preeclampsia-Eclampsia	24.0
Hemorrhage	22.3
Septic shock	7.6
Neoplasm	4.7
Embolism	4.2
Abortion	3.0

Source: The National Health Information System

To reduce MMR levels, the Mexican government has implemented several programs such as Oportunidades, Arranque Parejo en la Vida (An Equal Start in Life), Seguro Popular and Embarazo Saludable (Healthy Pregnancy). Figure 3 shows the time when each of these programs where implemented and the MMR trend from 1990 to 2010.

Oportunidades offers prenatal care to pregnant women as well as nutritional supplements during pregnancy and after birth to avoid malnutrition. However, only women who are beneficiaries of the Program receive these benefits. Arranque Parejo en la Vida (APV) aims to decrease maternal mortality by ensuring that a greater number of births take place in hospitals, by training traditional midwives and other medical personnel, and by improving medical infrastructure and facilities. Embarazo saludable is an additional component of AVP which focus on prenatal and postpartum care for women and their babies without access to health services. Finally, Seguro Popular offers health services to the entire population, including prenatal care, but focuses on uninsured people (Freyermuth and Sesia 2009; Mills 2006).

Figure 3. Programs implemented by the Mexican government

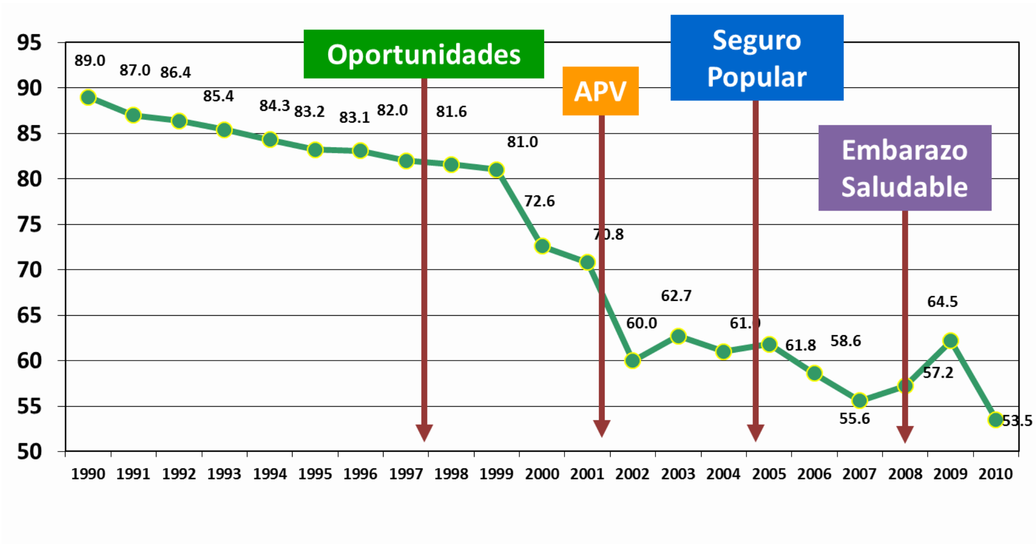
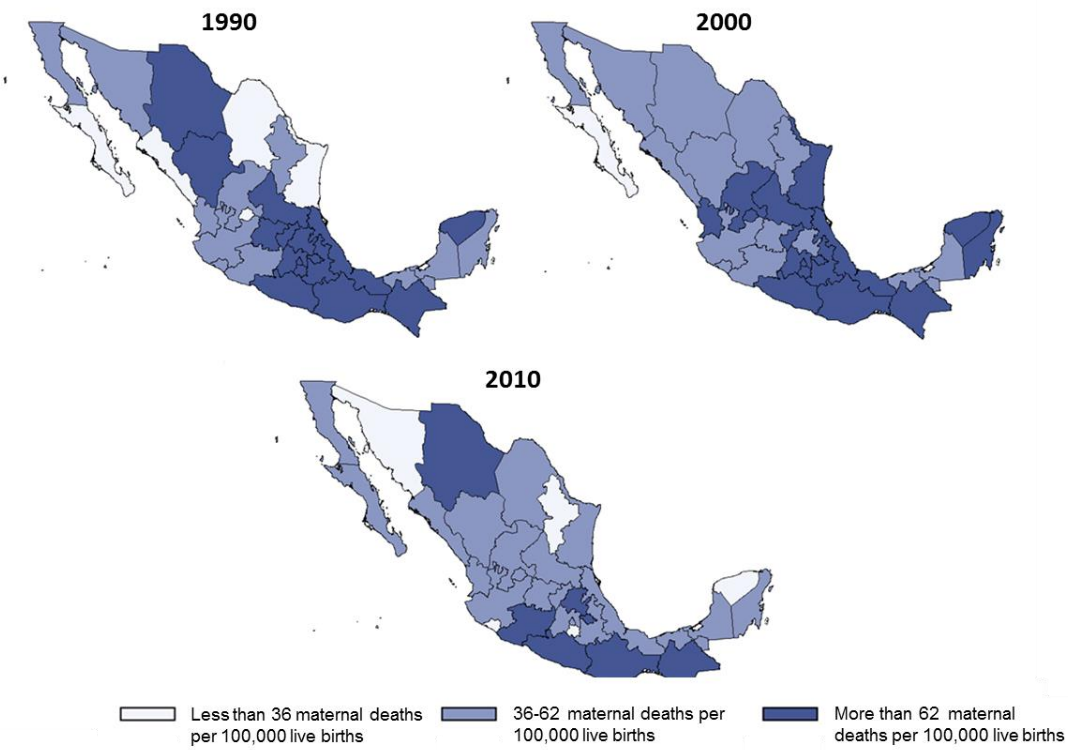


Figure 3 shows that the trajectory of the MMRs decreased rapidly after 1999, when most of the rural communities in the country were benefited by Oportunidades. After correcting the under estimation in 2002, the decreasing tendency stopped, and then in 2005 the rate started falling again. It might be the case that the effect of the different programs implemented after this correction is diluted as a consequence of the measurement change. Nonetheless, one of the impact evaluation studies of Oportunidades Program found that the incorporation of the Oportunidades Program in extreme poverty localities is related to an 11% reduction in maternal mortality (Hernández et al. 2003).

Several studies have found that teenagers, indigenous women, and women with less education have the highest risk of maternal mortality in the country (Freyermuth 2009; Freyermuth and Sesia 2009; Lozano et al. 2005). Thus, programs aimed at improving the health status of these populations might be instrumental in reducing maternal mortality in the country.

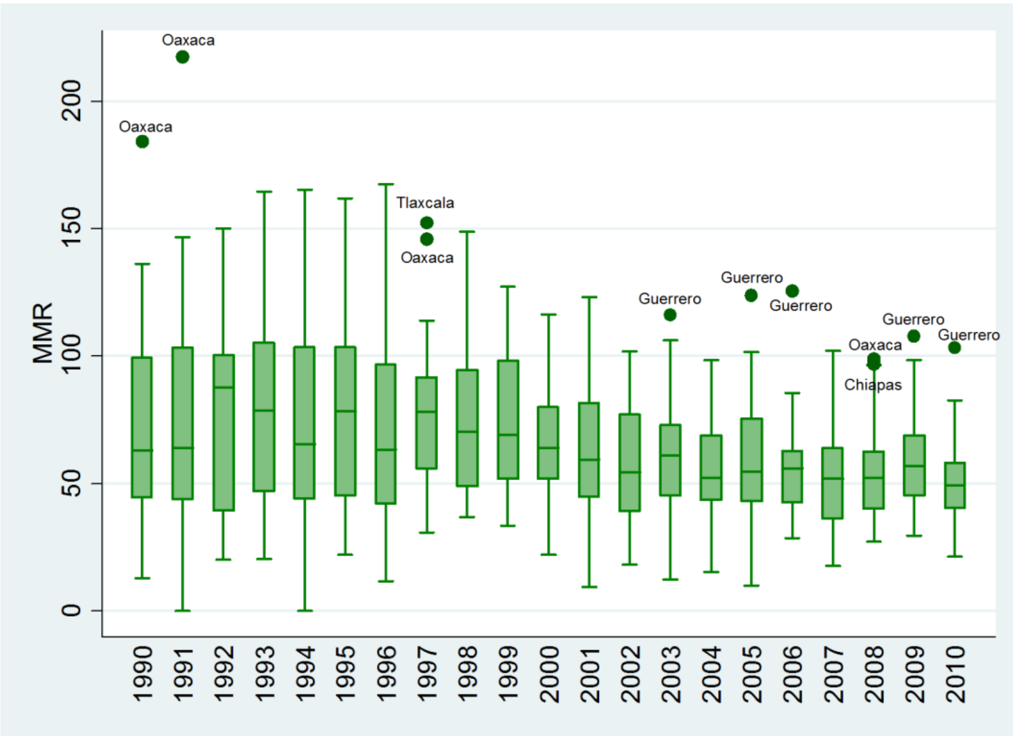
At the state level, Mexico presents very different levels of MMR. While poor states have higher levels of MMR, better-off states have lower MMRs. However, some states have higher levels of MMR than expected based on their poverty, which can be explained by the migration of women who seek health services (Cárdenas 2009b). Figure 4 illustrates the changes in MMR by state in 1990, 2000, and 2010. It can be seen that the southern states consistently experience the highest levels of maternal mortality.

Figure 4. Maternal Mortality Ratio (MMR) by State, 1990, 2000, and 2010



The differences between states' MMRs have varied over time (Figure 5). In 1990, Oaxaca had the highest MMR in the country (184.1 maternal deaths per 100,000 live births), which was almost 15 times higher than Coahuila's MMR. Coahuila had the lowest ratio in the country that year (12.7 maternal deaths per 100,000 live births). In 2010, the highest MMR (Guerrero, 103.2 maternal deaths per 100,000 live births) was only 5 times the lowest MMR (Nuevo León, 21.2 maternal deaths per 100,000 live births). It is important to notice that besides the correction of the number of maternal deaths after 2002, the highest MMR in 2010 is considerable lower than the highest MMR in 1990, which might be due to the programs implemented during this period or may be due to changes in measurement.

Figure 5. Maternal Mortality Ratio by State, 1990-2010



Although there is persistent variation between state MMRs, that variability has been declining over time. However, states like Guerrero and Chiapas still have very high MMRs (Figure 5). On the other hand, the lowest levels of MMR observed in 2010 are higher than the lowest level observed in 1990. This might be explained by the fact that maternal mortality data has been corrected since 2002 (Freyermuth 2009; Freyermuth and Cárdenas 2009; Lozano et al. 2005).

Data

To analyze the relationship between the MMR and state characteristics, I used data from the Mexican Millennium Development Goals Information System, the Mexican National Health Information System (SINAIS is its Spanish acronym); the 1990, 2000, and 2010 Mexican Censuses; and, the 1995 and 2005 Conteos.

The historical time series of MMRs and the proportion of births attended by skilled health personnel from 1990 to 2010, as well as the average number of prenatal visits made by pregnant women from 2000 to 2010, were obtained from the Mexican Millennium Development Goals Information System.

The public expenditure on health (from 1990-2010), the proportion of women of reproductive age using contraceptive methods, the proportion of C-section births, the total fertility rate, the teen fertility rate, and the proportion insured by state from 2000 to 2010 were obtained from the SINAIS.

The state level socio-economic variables were obtained from 1990, 2000, and 2010 Census data and from 1995 and 2005 Conteo data.

Finally, Oportunidades program implementation data were obtained from the program website. A state is considered "with Oportunidades" when the first wave of beneficiaries in the state have received their first cash transfer.

Measures

Since past research has shown that socioeconomic variables, access to prenatal care, health care providers, and family planning played an important role in reducing MMR (Prata et al. 2010; Romero et al. 2007; Cárdenas 2012), the covariates used in the present work aim to measure the state characteristics in each of the areas that previous research identified as important for reducing maternal mortality. I also include the state total fertility rate (TFR) as a measure of exposure to the risk of maternal mortality (Cárdenas 2012). Because there is evidence that teenagers and indigenous women face the highest risk of maternal mortality in the country (UNDP 2010; Freyermuth 2009; Freyermuth and Sesia 2009; Lozano et al. 2005), the state teen fertility rate and the proportion of population who speak an indigenous language in the state are also included. Finally, measures of government involvement are included: the total expenditure of health and an indicator of having Oportunidades Program beneficiaries.

To measure socioeconomic characteristics, I use the proportion of houses in the state with dirt floors, the proportion of houses in the state without in-house piped water, and the proportion of literate women in the state. The proportion of literate women is also a measure of female education which also plays a vital role in declining maternal mortality (Romero et al. 2007; Cárdenas 2012).

To measure access to prenatal care, I use the average number of prenatal visits made by pregnant women by state and the proportion of insured population. The proportion insured is also included as it is considered a proxy of the population with secure access to prenatal care in the state.

I used the proportion of births attended by skilled health personnel and the proportion of cesarean section births in the states as measures of access to health providers. The proportion of cesarean section births can be considered a health care measure because a low rate of C-section births may be an indicative of a deficient health care and a high C-section birth rate may be jeopardizing women’s health (Cárdenas 2012; UNDP 2010).

The state's proportion of women of reproductive age who are users of a contraceptive is my measure of access to family planning. Having access to effective contraceptive methods may enable women to avoid unwanted pregnancies which reduce the exposure to maternal death (Prata et al. 2010; UNDP 2010).

Descriptive Analysis

Table 2. Summary statistics by year

Variables	1990		2000		2010	
	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev
Socioeconomic variables						
Proportion of houses with dirt floor	0.200	0.120	0.133	0.098	0.061	0.045
Proportion of houses without in-house piped water	0.196	0.118	0.145	0.095	0.076	0.069
Proportion of literate women	0.849	0.088	0.889	0.068	0.914	0.051
Health care, health providers and family planning						
Average number of prenatal visits made by pregnant women	----	----	4.533	0.471	5.145	0.622
Proportion of insured population	----	----	0.533	0.143	0.468	0.146
Proportion of births attended by skilled health personnel	0.766	0.185	0.879	0.145	0.952	0.087
Proportion of cesarean section births	----	----	0.312	0.043	0.394	0.050
Proportion of women of reproductive age who are users of a contraceptive method	----	----	0.373	0.054	0.353	0.063
Population at risk						
Total fertility rate	3.475	0.594	2.469	0.233	2.306	0.206
Proportion of population who speak an indigenous language	0.084	0.120	0.077	0.103	0.069	0.092
Teen fertility rate	----	----	0.063	0.012	----	----
Government involvement						
State total health expenditure (in billions 2011 pesos)	3.372	5.239	7.152	11.800	13.143	15.949
With Oportunidades beneficiaries	----	----	0.969	0.177	1.000	0.000

Table 2 displays the summary statistics for the 1990, 2000 and 2010 data[2]. Overall, it shows that all variables improve over time. For instance, the proportion of houses with dirt floors and without in-house piped water decline over time; the average number of visits made by pregnant women, the proportion of births attended by skilled health personnel, the proportion of women of reproductive age who are users of a

[2] The summary statistics for all years are available upon request.

contraceptive method, and the state total health expenditure increases between 1990 and 2010.

Figure 6. Observed MMR vs. OLS estimated MMR by state

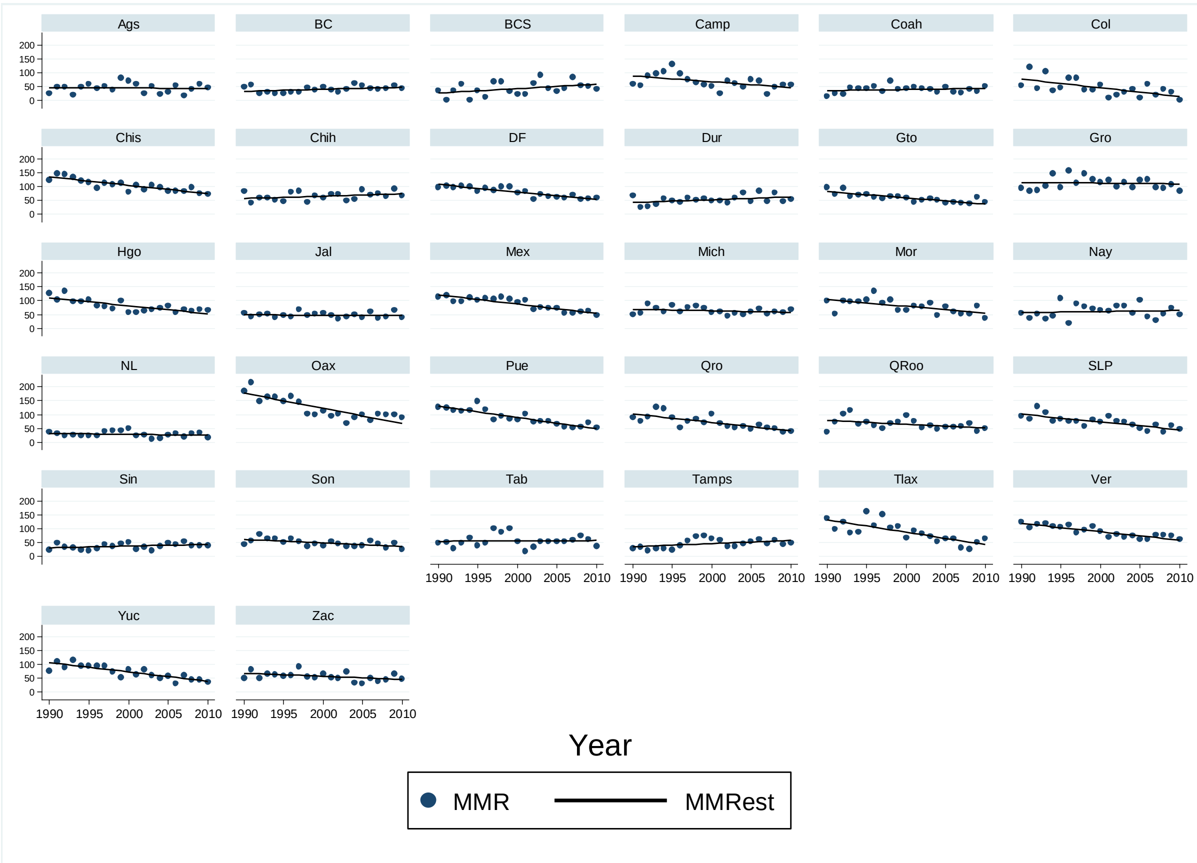


Figure 6 shows the unconditional MMR trajectory and the independently fitted OLS trajectories by state. Most of the fitted trajectories are declining over the analyzed period and the intercepts vary from 26 to 177 maternal deaths per 100,000 births.

Table 3 presents the summary statistics from the unconditional independent OLS regressions plotted in figure 6. There are 23 states with a slope significantly different from zero and three of those have a positive slope yet this slope is smaller than one. Nine states have non-significant slopes.

Table 3. Summary Statistics from Within-States Regressions

State	β_0	β_1	σ_ε^2	R^2
Aguascalientes	45.03***	-0.081	5680.417	0.001
Baja California	32.57***	0.73*	2019.768	0.167
Baja California Sur	26.08**	1.60*	10026.73	0.165
Campeche	88.11***	-2.08**	10362.89	0.244
Coahuila de Zaragoza	35.12***	0.39	3232.453	0.035
Colima	76.3***	-3.12***	11656.83	0.391
Chiapas	134.8***	-3.03***	2309.358	0.754
Chihuahua	56.75***	0.85	4011.574	0.121
Distrito Federal	107.4***	-2.73***	1542.572	0.788
Durango	42.38***	0.99**	3977.782	0.159
Guanajuato	81.56***	-2.23***	1817.828	0.677
Guerrero	114.9***	-0.27	8704.783	0.007
Hidalgo	109.6***	-2.87***	3898.734	0.619
Jalisco	48.55***	-0.17	1623.313	0.014
México	120.5***	-3.35***	2316.757	0.789
Michoacán de Ocampo	68.53***	-0.57	2721.108	0.083
Morelos	102.6***	-2.35***	7838.489	0.353
Nayarit	56.26***	0.39	10924.46	0.011
Nuevo León	31.61***	-0.32	1619.774	0.046
Oaxaca	177.1***	-5.46***	9248.549	0.713
Puebla	130.2***	-4.10***	3306.08	0.796
Querétaro	102.3***	-3.07***	5510.923	0.568
Quintana Roo	78.68***	-1.36*	6403.475	0.183
San Luis Potosí	100.9***	-2.78***	3990.017	0.598
Sinaloa	30.56***	0.61*	1567.985	0.154
Sonora	60.57***	-1.24***	1940.643	0.38
Tabasco	53.92***	0.14	8500.984	0.002
Tamaulipas	34.67***	1.11**	3723.345	0.202
Tlaxcala	131.2***	-4.46***	11094.63	0.58
Veracruz de Ignacio de la Llave	117.8***	-2.96***	1832.436	0.787
Yucatán	106***	-3.36***	3425.538	0.717
Zacatecas	67.49***	-1.09**	3776.569	0.196

*** p<0.01, ** p<0.05, * p<0.1

Mean	80.314	-1.445	5018.963
Std. dev.	38.428	1.877	
Pearson correlation coefficient	-0.906		

The correlation between the intercepts (β_0) and the slopes (β_1) shows some evidence of negative association between initial status and rate of change.

Methods

I used an unconditional means model to evaluate the relative magnitude of the between-states and within-states variance components, an unconditional growth model to assess the difference between and within states trajectories, and multilevel model of change to observe the relationship between state characteristics and maternal mortality across time. The outcome variable for all models is the state-level annual maternal mortality rate.

The unconditional means model estimates the true grand mean (γ_{oo}) and the true state-specific mean (β_{0j}). This model also provides the within-state variance (ε_{ij}) and the between-states variance (u_{0j}):

$$MMR_{ij} = \beta_{0i} + \varepsilon_{ij}$$
$$\beta_{0i} = \gamma_{oo} + u_{0i}$$

Assuming that $\varepsilon_{ij} \sim N(0, \sigma_\varepsilon^2)$ and $u_{0i} \sim N(0, \sigma_0^2)$

The unconditional growth model includes a time predictor into the level 1 model which allows the estimation of state average rates of change.

$$MMR_{ij} = \beta_{0i} + \beta_{1i} TIME_{ij} + \varepsilon_{ij}$$
$$\beta_{0i} = \gamma_{00} + u_{0i}$$
$$\beta_{1i} = \gamma_{10} + u_{1i}$$

Assuming that $\varepsilon_{ij} \sim N(0, \sigma_\varepsilon^2)$ and $\begin{pmatrix} u_{0i} \\ u_{1i} \end{pmatrix} \sim N \begin{pmatrix} \sigma_0^2 & \sigma_{01} \\ \sigma_{10} & \sigma_1^2 \end{pmatrix}$

In order to observe the relationship between MMR and state characteristics, I also fitted growth curve models with time varying predictors. The present analysis only uses covariates for the intercept equation. Then, the composite specification used in the present analysis is the following:

$$MMR_{ij} = [\gamma_{00} + \sum_{k=1}^{n} \gamma_{0i_k} x_{ij_k} + \gamma_{10} TIME_{ij}] + [u_{0j} + u_{1j} TIME_{ij} + \varepsilon_{ij}]$$

Where x_{ij_k} represents the k time-varying covariate for state i at time j.

Results

Model A in Table 4 presents the results of fitting the unconditional means model to the state MMR data. Its fixed effect (γ_{00}) estimates the grand mean across all years and states. The main purpose of fitting this model is to examine the random effects. The estimated within-states variance (σ_ε^2) is 487.1; the between states variance (σ_0^2) is 454.3. Both variances are significant at the 0.01 level, so it can be conclude that the average state's MMR varies over time and states differ from each other in MMR level.

The unconditional means model allows us to evaluate numerically the relative magnitude of the within-states and between-states variance components. Thus, I can calculate the intraclass correlation coefficient, which indicates that about 48% of the variation in MMR is attributable to differences between states.

Model B in Table 4 presents the results of fitting the unconditional growth model to the state MMR data. The fixed effects, γ_{00} and γ_{10}, estimate the starting maternal mortality ratio and the slope of the states average change trajectory. The estimated starting point is 80 deaths per 100,000 live births, which is classified as high and is statistically different from zero ($p<0.01$). The slope of the states average change trajectory is negative and significant at the 0.01 level, which suggests that the average rate of change has been declining over time.

Table 4. Unconditional Multilevel Models for Change

Fixed Effects		**Model A**	**Model B**
Initial Status β_{0i}	Intercept, γ_{00}	65.860** (3.974)	80.315** (6.687)
Rate of change β_{1i}	Intercept, γ_{10}		-1.445** (0.327)
Variance components			
Level 1	Within states, σ_ε^2	462.85**	264.16**
Level 2	In initial status, σ_0^2	483.38**	1383.83**
	In rate of change, σ_1^2		3.07**
	Covariance, σ_{01}		-59.18**

** p<0.01, * p<0.05, † p<0.1

Comparing the estimated σ_ε^2 in Model B to that in Model A, I find a decline of 0.43. I can conclude that 43% of the within-state variation in MMR is systematically associated with linear time. Because this variance component is statistically significant, I also know that some important within-state variation still remains at level-1. Models C to G include level-2 predictors in order to explore the relationship between the initial levels of MMR and the covariates that past research has found to play an important role in reducing maternal mortality.

Table 5. Growth curve models with state-level covariates

Variables	Model C	Model D	Model E	Model F	Model G
Time	-0.531†	-0.002	-0.190	-1.475**	0.978
	(0.31)	(0.42)	(0.71)	(0.31)	(0.76)
Socioeconomic variables					
Houses with dirt floor	68.58**				11.54
	(26.03)				(47.60)
Houses with no piped-water	-41.88				66.42†
	(28.17)				(39.74)
Literate women	-188.38**				-21.19
	(54.49)				(73.58)
Health related variables					
Average number of prenatal visits made by pregnant women		-2.08			-3.43
		(1.98)			(2.28)
Insured population		-9.89**			-6.31
		(6.86)			(7.79)
Births attended by skilled health personnel		-81.76**			-13.80
		(16.36)			(24.35)
C-section births		-57.67†			-40.22
		(31.43)			(34.81)
Users of contraceptive methods		-5.20			-22.48*
		(7.71)			(11.16)
Population at risk					
State TFR			29.23†		26.06†
			(15.57)		(15.65)
Indigenous population			93.42**		37.32
			(24.05)		(23.39)
Teenagers' fertility rate			-224.75		-218.31
			(206.18)		(228.08)
Government involvement					
State total health expenditure				-0.013	0.25
				(0.18)	(0.16)
With Oportunidades beneficiaries				-9.14**	-9.63
				(2.74)	(11.69)
Intercept	232.48**	170.39**	1.03	89.28**	67.35
	(53.40)	(16.35)	(35.04)	(5.97)	(80.73)
Random-effects Parameters					
Level 1 Within states, σ_{ε}^2	261.42**	170.87**	172.55**	185.08**	170.64**
	(15.01)	(14.32)	(16.35)	(13.36)	(16.29)
Level 2 In initial status, σ_0^2	602.50**	588.47**	1015.66**	942.73**	1016.37**
	(175.47)	(244.77)	(404.15)	(276.66)	(431.03)
In rate of change, σ_1^2	2.22**	1.71*	3.67*	1.65**	4.07*
	(0.65)	(0.83)	(1.66)	(0.62)	(1.83)
Covariance, σ_{01}	-33.49**	-29.10*	-56.46*	-34.54**	-62.82*
	(10.22)	(13.84)**	(25.21)	(12.33)	(27.58)

** p<0.01, * p<0.05, †p<0.1

Note: Standard errors between parentheses

Four models were fitted each using a different collection of related variables in order to observe how each overall characteristic relates to the MMR trajectory. Model C only includes socioeconomic variables at the state level, model D uses only variables related to health such health care access, including health care providers and contraceptive users. Model E includes only population at risk variables, and Model F includes only government involvement variables. The final model, F, includes all variables together.

Model C shows that the proportion of houses in the state with dirt floors and the proportion of literate women are significantly related to the maternal mortality rate. The proportion of houses with dirt floors is negatively related to the MMR, as expected. The proportion of literate women in the state is negatively related to the level of maternal mortality and its coefficient is more than twice the coefficient of dirt floor variable in absolute terms, which highlights the importance of women's education in reducing maternal mortality. Once controlling for socioeconomic variables, γ_{10} represents the annual rate of change in MMR which is still negative but no longer significant. In fact, its magnitude reduces considerably.

Including only health variables in Model D also reduces the magnitude of the annual rate of change in MMR, which remains negative and non-significant. All coefficients for this set of variables are negative as expected but only the proportion of births attended by skilled health personnel is significant at the 0.05 level.

In Model F, controlling for population at risk variables, the annual rate of change in MMR also lost significance and decreased in magnitude. However, these changes were not as pronounced as in the previous models. The coefficients for TFR and indigenous populations are positive as expected; however only the coefficient for indigenous population is significant at 0.05 level.

Model F includes government involvement variables. The annual rate of change in MMR controlling for these variables is very close in magnitude to the one in Model B and remains significant, which suggest that these variables do not explain the observed decline in MMR. Both variables have negative coefficients but only the indicator of Oportunidades beneficiaries is significant at the 0.05 level.

Finally, Model G includes all variables at once. The annual rate of change in this case is positive but non-significant. All variables have the expected sign except for teenager's specific fertility rate and total public expenditures in health. There is only one variable significant at the 0.05 level: proportion of women in reproductive age who are contraceptive users. On average for every additional percentage point in the percent of users of contraceptive methods, the annual MMR decreases by 22.5, controlling for socioeconomic, health related, population at risk, and government involvement variables.

Conclusion

Mexico still has much work to do to achieve the goal of declining the 1990 MMR by three quarters. At the state level, it is clear that the poorest states have to make an extra effort to attain this goal. Fortunately, the Mexican government is aware of the disadvantage of these states and its efforts have targeted the poorest areas in the country. Yet the disadvantage persists.

The unconditional models presented here describe what has happened over the last 20 years regarding maternal deaths. As these models indicated, understanding these changes requires understanding conditions at the state level. Past research has pointed out significant characteristics, which has informed the present models. Although I cannot claim causality, I observe that in most of the cases, the association follows the expected trajectory except for teenagers' specific fertility rate which always shows a negative sign opposed to the expected positive relationship. Importantly, however, this variable was never significant.

Women's education has been found highly and negatively related to levels of maternal mortality (Freyermuth 2009, Romero et al 2007). Women's literacy seems to play a role in reducing MMR but the results were not significant in all models.

Contraception seems to play an important role in reducing levels of maternal mortality, since the proportion of contraceptive users in the state has a significant relationship with the maternal mortality ratio in the final model. The use of contraceptive methods helps to reduce pregnancies at extreme ages, to facilitate optimal spacing between pregnancies, and to prevent unintended pregnancies which might reduce maternal mortality by reducing the number of women exposed to the risk of dying during pregnancy or childbearing and the risk of adverse maternal outcomes. However, the present work does not include a measure of unmet need for contraception, method mix, or a direct measure of access, all of which could provide a more accurate description of the effect of unequal access to contraception.

One of the limitations of the present study is the lack of information for the 1990's period for most of the state variables. The results can only depict the relationship between maternal mortality ratio and state variables during the 2000's which deprives us of knowing how this relationship was in the decade when a steady decline was observed (Figure 1) and also when Oportunidades Program (then known as Progresa) was first implemented. Because evaluation studies have shown evidence that the program helped to reduce maternal mortality (Hernández et al 2003), this is a limitation.

Although the Mexican government has developed several programs to attain the maternal mortality reduction Millennium Goal, it seems that these efforts won't be enough. However, it is important to consider the fact that the goal was set using an artificially low rate. In addition, the 2009 H1N1 Influenza outbreak in Mexico increased the levels of maternal mortality in the country (Health ministry 2010, 2011b).

Maternal mortality mirrors the social and gender inequality faced by the most disadvantaged populations in a specific region. Across the world, women living in poverty, with limited access to health services, low education and who do not enjoy full reproductive rights have the highest risk of maternal death. There have been different strategies to reduce levels of maternal mortality but the multidimensional nature of the problem has complicated this task. However, there is evidence that when women are able to fully exercise their reproductive rights, the risk of maternal death decreases. Therefore, improving women's education and access to contraception might be an essential part of any strategy to reduce maternal mortality levels.

References

Beck, S., D. Wojdyla, L. Say, A. P. Betran, M. Merialdi, J. H. Requejo, C. Rubens, R. Menon, and P. F. A. Van Look. 2010. "The worldwide incidence of preterm birth: a systematic review of maternal mortality and morbidity." *Bulletin of the World Health Organization* 88:31-38.

Cárdenas, Rosario. 2012. "La reducción de la mortalidad materna: un desafío para la salud pública." Presented at the V Latin American Population Association Congress, October 24, Montevideo, Uruguay.

Cárdenas, Rosario. 2009a. "Indicadores Selectos para la Evaluación de las Condiciones de Salud." Comité promotor para una maternidad sin riesgos, México.

______. 2009b. "Los Servicios de Salud y la Mortalidad Materna." Maternidad sin riesgos, Mexico city.

Freyermuth, Graciela. 2009. "Maternal Mortality. Institutional Inequity and Inequality Among Women." CNDH, CIESAS, CONEVAL, Mexico, D.F.

Freyermuth, Graciela and Rosario Cárdenas. 2009. "Assessment of maternal mortality underreporting in Los Altos de Chiapas using RAMOS and RAMOS modified methods." *Salud Publica De Mexico* 51:450-457.

Freyermuth, Graciela and Paola Sesia. 2009. "Maternal death. Actions and strategies towards safe motherhood." Comité Promotor por una Maternidad sin Riesgos en México, México.

Health Ministry. 2010. "México avanza en el cumplimiento de las metas del milenio." (Mexico advances in meeting the Millennium Development Goals). [Press release]. Retrieved from http://www.salud.gob.mx/ssa_app/noticias/datos/2010-07-28_4697.html

______. 2011a. "Boletín Epidemiológico." (Epidemiology Bulletin). Mexico: Secretaría de Salud.

______. 2011b. "Mortalidad Materna en México durante 2009. El efecto de las infecciones respiratorias agudas (neumonía e influenza)." (Maternal Mortality in Mexico during 2009. The effect of acute respiratory infections (pneumonia and influenza)). In Dirección General de Información en Salud (Ed.). Mexico: Secretaría de Salud.

Hernández, Bernardo, Dolores Ramírez, Hortensia Moreno, and Nan Laird. 2003. "Evaluación del impacto de Oportunidades en la mortalidad materna e infantil." Instituto Nacional de Salud Pública, Cuernavaca.

Liljestrand, Jerker and Indra Pathmanathan. 2004. "Reducing Maternal Mortality: Can We Derive Policy Guidance from Developing Country Experiences? Critical Elements in Reducing Maternal Mortality." *Journal of Public Health Policy* 25:299-314.

Lozano, Rafael, Rosa María Nuñez, María Beatriz Duarte, and Luis Manuel Torres. 2005. "Evolución y tendencias de largo plazo de la mortalidad materna en Mexico: análisis de factibilidad y de efecto potencial de intervenciones seleccionadas para el cumplimiento de las metas del milenio." in *México, ante los desafíos de desarrollo del milenio*, edited by E. Zuñiga. Mexico city: CONAPO.

Mills, Lisa. 2006. "Maternal health policy and the politics of scale in Mexico." *Social Politics* 13:487-521.

Notimex, 2011. “Mortalidad materna, meta pendiente: SSA”. *Azteca Noticias*. Retrieved March 5th, 2013, from (http://www.aztecanoticias.com.mx/notas/salud/69761/mortalidad-materna-meta-pendiente-ssa)

Prata, Ndola, Paige Passano, Amita Screenivas, and Caitlin E. Gerdts. 2010. "Maternal mortality in developing countries: challenges in scaling-up priority interventions." *Women's Health* 6:311-327.

Presidencia de la República. 2011. "Los Objetivos de Desarrollo del Milenio en México: Informe de Avances 2010." Mexico city.

Romero, Gustavo, Andrés Espitia, Ana Lilia Ponce, and Luis Fernando Huerta. 2007. "Risk factors of maternal death in Mexico." *Birth-Issues in Perinatal Care* 34:21-25.

Saldierna, G. 2011. “México no cumplirá con metas para abatir la mortalidad materna, admite el Conapo.” *La Jornada*, July 8, p. 44. Retrieved from (http://www.jornada.unam.mx/2011/07/08/sociedad/044n1soc)

UNDP. 2010. "Las mujeres y el presupuesto público en México." United Nations Development Programme, Mexico city.

World Health Organization. 2010. "World Health Statistics 2010." WHO press.